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Translucent Flesh Disorder of Mangosteen Fruit (*Garcinia mangostana* L.)

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***Abstract.* Characteristics of mangosteen fruit with normal and translucent flesh were determined. Fruit exhibiting translucent flesh disorder had significantly higher rind (65%) and flesh (82%) water content than fruit with normal flesh (63% and 80% in the rind and flesh, respectively). Specific gravity of translucent flesh fruit was >1 and that of normal flesh fruit was <1. Fruit specific gravity and natural transverse rind cracking were used to separate translucent-fleshed fruit from normal fruit. Translucent-fleshed fruit had a lower soluble solids concentration and titratable acid percentage than normal fruit. Translucent flesh was induced in normal fruit following water infiltration at 39 kPa for 5 minutes.**

Translucent flesh disorder of mangosteen is a major cause of reduced fruit quality. Symptoms, usually found in large segments (carpels) of the fruit, include flesh changes from white to translucent and textural changes from soft to firm and crisp. Translucent-fleshed fruit cannot be separated from normal fruit by external (rind) appearance, although some affected fruit have a transverse crack on the rind. Causes of this disorder are unclear (Tonboonake et al., 1978; Tongdee, 1992; Wannasiri, 1990); however, three causes have been suggested: 1) mechanical injury due to poor harvesting and handling practices (Phlompaat, 1989), 2) nutrient imbalance (Phlompaat, 1989), and 3) pathogens (Wannasiri, 1990). Also, we have observed that the number of translucent-fleshed fruit usually increases after heavy rains.

Similar to water core in apples (*Malus domestica* Borkh.) (Gardner et al., 1952), the affected mangosteen tissue becomes hard and glassy. Marlow and Loescher (1984) suggested that water core development is a maturation phenomenon related to leaky membranes or altered transport in susceptible cultivars. Sapii and Nathachai (1994) reported that wet core in durian (*Durio zibethinus* Murr.) was caused by heavy rain; the core and pulp were soft due to excess moisture. To our knowledge, other factors affecting wet core in durian have not been defined.

Our objectives were to 1) investigate mangosteen fruit water uptake and 2) devise a method to separate translucent from normal fruit using specific gravity.

Materials and Methods

Mangosteens (3224 fruit, ≈180 kg) were purchased from a wholesale market and separated into two groups based on whether they floated or sank in tap water. Fruit that floated were separated further into two subgroups, peduncle and calyx under the surface of the water and peduncle and calyx at the surface of the water. The number of fruit in each group was recorded. Damaged fruit were discarded.

Naturally cracked fruit were opened to determine flesh condition. Fruit specific gravity was measured by water displacement for 30 randomly selected fruit from each group. Thirty additional fruit were randomly sampled from each group for weight and diameter measurements of the fruit and flesh (rind removed). Fifteen randomly selected fruit from the floating group (peduncle and calyx under the water surface) were subjected to vacuum water infiltration at 39 kPa for 5 min.

Fruit from a given group were sliced, and the number of normal and translucent flesh fruit were recorded. Floating fruit with translucent flesh and sinking fruit with normal flesh were not included in subsequent analyses.

Thirty fruit were randomly sampled from each of the floating and sinking fruit groups, each fruit was separated into 1) rind, 2) calyx and peduncle, 3) flesh, and 4) seed, and each part was weighed. Following drying at 65C for 48 h, percent dry weights were calculated.

Percent edible flesh of translucent- and normal-fleshed fruit was calculated from 30 fruit in each group. Flesh juice acidity, titratable acids (TA) as citric acid (titrated with 0.987 N NaOH), and soluble solids concentration (SSC) [measured by refractometer (model 3B; Bausch and Lomb, Rochester, N.Y.)] were determined from 30 fruit of each group.

The experiment was a completely randomized design, with individual fruit of each group as a replication. All data were analyzed using analysis of variance and means were separated by *t* test and paired *t* comparisons at $P < 0.05$ (SAS Institute, 1985).

Results and Discussion

Of total fruit, 66% floated, while 34% sank, in water. All fruit with natural transverse rind cracks sank and displayed translucent flesh. Rind cracks may have been caused by turgor pressure inside the fruit, as reported for other fruit (Brown and Considise, 1982). Cracked fruit had translucent flesh in all segments; fruit without cracks that sank had all or only the large segments translucent.

A higher percentage of fruit that floated had normal flesh (Table 1). Fruit that sank had a higher percentage of fruit with translucent flesh. Only 23% of the fruit with translucent flesh that sank had cracked rinds. When the two groups of floating fruit were compared, 4% of the fruit with the peduncle and calyx under the water surface had translucent flesh, but 60% of the fruit with the peduncle and calyx at the water surface had translucent flesh.

The average weight (74 g), diameter (5 cm), and weight : diameter (14.8 g•cm^{-1}) ratios of crack-free fruit that floated and sank were

Table 1. Soluble mangosteen fruit constituents and percentage of normal- and translucent-fleshed fruit that floated or sank.

	Constituents			Fruit (%)	
Flesh	SSC (%)[z]	TA (%)[y]	SSC : TA	Floated	Sank
Normal	19 a[x, w]	0.38 a	50.0 a	91 a	25 b
Translucent	17 b	0.29 b	58.0 b	9 b	75 a[x]

[z]SSC = soluble solids concentration.
[y]TA = titratable acidity, as citric acid, the predominant acid.
[x]Fruit (23%) in this group were cracked.
[w]Mean separation in columns by *t* test at $P \leq 0.05$.

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similar (data not shown). Flesh weight (28 g), flesh diameter (4 cm), and the flesh weight : diameter ratio (7.0 $g{\cdot}cm^{-1}$) of the two fruit groups were similar.

The edible flesh percentage of normal- and translucent-fleshed fruit were similar (data not shown). However, specific gravity of whole normal fruit was lower (0.95) than that of fruit that sank (1.01).

Normal-fleshed fruit had higher SSC and TA than fruit with translucent flesh, and the SSC : TA ratio of normal flesh fruit was lower than that of fruit with translucent flesh (Table 1). Rind and flesh dry weights of fruit with translucent flesh were lower than those of fruit with normal flesh (Table 2). Dry weights of the seed and the calyx with peduncle were similar for both types of fruit (Table 2).

Fruit from the floating group sank after vacuum water infiltration, and the flesh was translucent, firmer, and contaminated with yellow gum from the rind. Weight and specific gravity of whole fruit and of flesh also increased (Table 3).

Translucent flesh of mangosteen may be similar to wet core in durian that occurs after excessive water uptake during heavy rain (Sapii and Nathachai, 1994). When water was infiltrated into mangosteen fruit, the flesh became translucent and the specific gravity increased. All cracked fruit sank, indicating higher specific gravity. Cracking could be related to internal turgor pressure, similar to skin cracking in other fruit (Brown and Considine, 1982). Gum may have been released from broken resin ducts. Fruit that floated in water were likely to be normal, while fruit that sank were likely to contain translucent flesh. Fruit that had translucent flesh floated only because air bubbles were either trapped under the calyxes or air spaces existed inside the fruit between the flesh and the rind. The higher water content, as inferred from the lower dry weight percentage in the rind of normal-fleshed fruit compared to that of translucent fruit, may have induced sinking of fruit with normal flesh. Increasing water density by adding sucrose, NaCl, or other solutes may increase efficiency of fruit separation. The possibility of water status interactions with other factors, such as mineral content and fruit maturation changes, should be investigated.

Table 2. Dry weights of normal- and translucent-fleshed mangosteen fruit.

Fruit	Dry wt (%)	
parts	Normal	Translucent
Rind	37.0 a[z]	35.0 b
Flesh	20.0 a	18.0 b
Seed	26.0 a	24.0 a
Calxy with peduncle	35.0 a	33.0 a

[z]Mean separation in rows by *t* test at $P \leq 0.05$.

Table 3. Weight, specific gravity, and percentage increase of mangosteen fruit and fruit flesh (without rind) before and after water infiltration at 39 kPa for 5 min.

Fruit	Water infiltration		Increase
part	Before	After	(%)
Weight (g)			
Whole	79 a[z]	82 b	3.8
Flesh	30 a	31 b	3.3
Specific gravity			
Whole	0.98 a	1.05 b	7.1
Flesh	1.03 a	1.07 b	3.9

[z]Mean separation in rows by paired *t* comparison at $P \leq 0.05$.

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